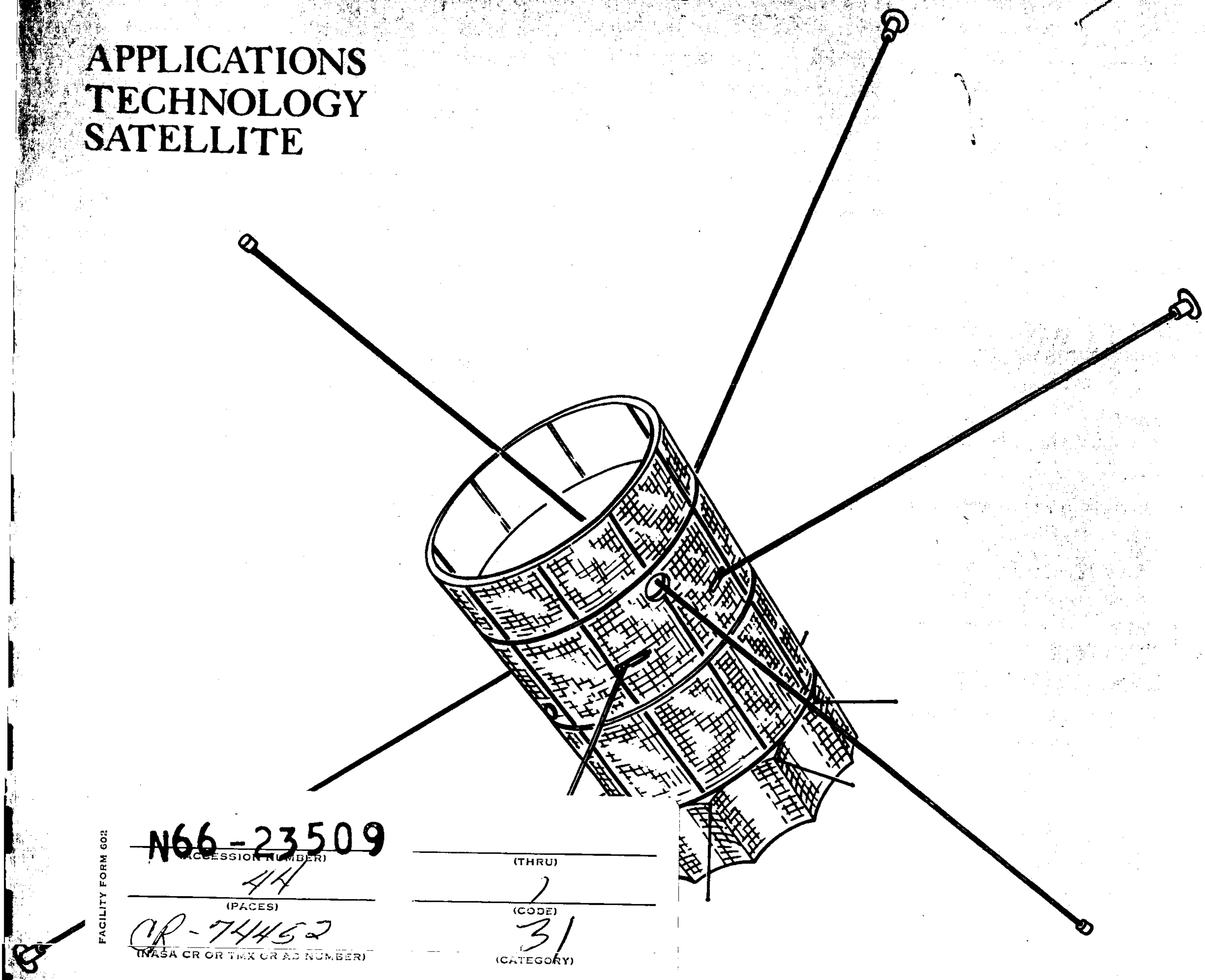
GRAVITY GRADIENT STABILIZATION SYSTEM for the APPLICATIONS TECHNOLOGY SATELLITE

DOCUMENT NO. 65SD4243
10 MARCH 1965



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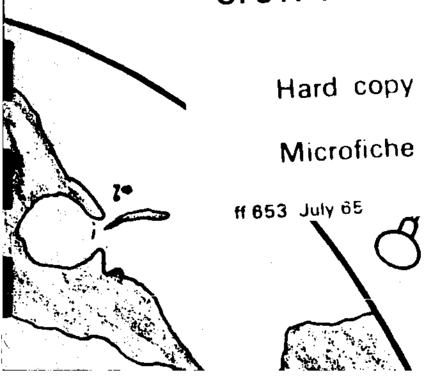

EIGHTH MONTHLY PROGRESS REPORT

NASA CONTRACT NAS 5-9042

GENERAL ELECTRIC
SPACECRAFT DEPARTMENT

DOCUMENT NO. 65SD4243
10 MARCH 1965

GRAVITY GRADIENT STABILIZATION SYSTEM
FOR THE
APPLICATIONS TECHNOLOGY SATELLITE
EIGHTH MONTHLY PROGRESS REPORT

1 FEBRUARY THROUGH 28 FEBRUARY, 1965

CONTRACT NO. NAS 5-9042

FOR THE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

JOHN M. THOLE
ATS TECHNICAL OFFICER

Approved By: R. J. Katucki, Manager
Passive Attitude Control Programs

GENERAL ELECTRIC
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P.O. Box 8555 • Philadelphia 1, Penna.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont)

LIST OF ILLUSTRATIONS

SECTION 1.

INTRODUCTION

1.1 PURPOSE

This report documents the Eighth Month of progress toward the design of the ATS Gravity Gradient Stabilization System. The report covers the period from February 1 to February 28, 1965.

1.2 SCOPE

Under Contract NAS 5-9042, the Spacecraft Department of the General Electric Company has contracted to provide Gravity Gradient Stabilization Systems for three Applications Technology Satellites: one to be orbited at 6000 nautical miles and two to be orbited at synchronous altitude. The gravity gradient stabilization systems will consist of the stabilizing boom and dampers, attitude sensors, and power control and interface electronics.

SECTION 2.

WORK PERFORMED

2.1 SYSTEMS ANALYSIS AND INTEGRATION

2.1.1 G^2S/ATS MATH MODEL

Dynamical equations, including second derivatives, have been derived. Work in progress includes orbit (umbra and penumbra effects) and spacecraft shadow subroutines. Major problem area in future efforts centers on establishment of a definitive model for rod thermal bending - the current model (GAPS III) is restricted to bending in the plane of the sun vector.

2.1.2 ATTITUDE DETERMINATION PROGRAM

Efforts continue on the generation of an Attitude Determination Program Design Specification. Primary emphasis, however, is still being placed on the completion of the sensor system error analysis . Analyses completed since the last monthly progress report include antenna polarization/sun sensor measurements and antenna polarization/RF sensor measurements. In progress are analyses of antenna polarization/earth sensor measurements and use of TV as a back-up attitude sensor. Preliminary conclusions (based strictly on analytical reasoning and neglecting problems of hardware implementation, cost, development schedules, etc.) can be summarized as follows:

1. The RF sensor/antenna polarization measurement system offers the best advantage, analytically, of all combinations considered to date. Complete attitude determination relative to a single line-of-sight requires only a simple coordinate transformation to get pitch, roll, and yaw attitude data. Errors are relatively flat over the entire range of ground station coverage. If antenna polarization measurements can be provided at acceptable rates and accuracies and if the RF sensor/boom interference problem could be resolved satisfactorily (and the RF sensor, in addition, could be

shown to meet acceptable cost and schedule criteria) this combination would be the recommended prime attitude sensing system.

2. As a close second to the RF sensor/antenna polarization measurement scheme, the earth sensor/antenna polarization measurement system offers the next best choice. ("earth sensor," here, is used in the general sense to indicate any sensor which measures spacecraft attitude with respect to the earth's local vertical. The particular earth sensor choice should be based on definitive tradeoffs between accuracy, cost, development time, utility, etc.) Under consideration as an "earth sensor" are STL's "Reliable Earth Sensor," GE's albedo sensor, and a variety of earth horizon scanners and "dither" devices. This combination of sensors also offers the advantage of a relatively flat error profile over the range of ground station coverage.

3. The solar aspect sensor/antenna polarization measurement and the solar aspect sensor/earth sensor (or RF sensor) measurement systems each have error profiles which tend to "blow up" (approach indeterminate solutions) under certain orbit position geometries. However, a judicious combination of the two systems allows the "blow up" regions to be avoided. In addition, when the earth sensor is inoperative due to the sun being in its field of view (prior to and following earth eclipse), the solar aspect sensor/antenna polarization measurements are near optimum. Hence, with either of the systems of (1.) or (2.) above, the solar aspect sensor represents an excellent choice for a secondary attitude sensing system. (Without antenna polarization measurements at acceptable rates and accuracies, the solar aspect sensor/earth sensor would be the prime choice.)

4. The TV system, used primarily to obtain boom thermal bending and boom dynamics data, can be used to advantage to resolve potential ambiguities in other sensor systems, to provide real time attitude displays at the ground stations, and to provide independent confirmation of attitude determined by combinations of other sensors.

Equations for the above sensor combinations will be documented in the next quarterly report.

2.1.3 ORBIT TEST PLAN

A preliminary Flight Data Evaluation Plan is in preparation. This and a revised and updated orbit test sequence will be included in the next quarterly report.

2.1.4 ORBIT TEST SIMULATION EXERCISE

Plans for contributing to (and participating in) an orbit test simulation exercise during the months immediately preceding the MAGGE launch have been dropped (per NASA's request). The exercise is now limited to an in-house checkout of GE computer programs and personnel related duties associated with the operation of those programs.

2.1.5 SYSTEM REQUIREMENTS STUDIES

The GAPS III program has been modified to allow an evaluation of effects due to the offset damper boom and station-deeping thrusters. This will provide the necessary tool for establishment of certain alignment tolerances. An analysis of internal disturbance profiles is nearing completion and is expected to result in a general specification of acceptable tolerances. The characteristic equation for linearized (small angle) motion of ATS - type configurations has been programmed and checked by comparison with results of a similar analysis by Tinling and Merrick of Ames Research Center. The program is now being utilized in steady state pointing accuracy optimization studies. The study of "uncoupled," two-damper system has also been initiated for comparison with performance of ATS-type configurations.

2.1.6 ANALYTICAL STUDIES AND RESULTS

A preliminary, analytical model of the ATS hysteresis damper has been developed and is being programmed for comparative evaluation with eddy current damping in the GAPS III program. The spacecraft response to isolated disturbance torques ("original" vs. "revised" spacecraft configurations) was generated as an input to current configuration tradeoffs at HAC. Shell equations, presented in the last quarterly report, are being programmed for a comparative evaluation of beam theory equations currently in use for boom thermal bending predictions. The end goal of the shell analysis is to confirm on deny current prediction methods for in-plane bending components.

2.1.7 TEST REQUIREMENTS AND PERFORMANCE

Major emphasis is being given to the definition of component alignment tolerances and measurement techniques.

As reported in the Seventh Monthly Progress Report (paragraph 2.5.1) difficulty was encountered in maintaining mirror alignment while the epoxy used for bonding was curing. Therefore the new system alignment procedures will not include the attachment of the target mirror to the component by means of epoxy for the following reasons:

1. Adherence of a target to a component by epoxy would require a development program to perfect an installation procedure.

2. Present thermal requirements require a thermal coating on the alignment surface, thus preventing a permanent target mirror installation.

Present studies indicate that removable target fixtures are the best solution to the alignment requirement.

A maximum 100 pole-cm magnetic diploe requirement has been placed on each ATS component. All acceptance tests of prototype and flight assemblies will now include a magnetic dipole test.

A formal request has been made to NASA/GSFC for waivers to the thermal test requirements for component qualification in NASA Specification S2-0102. The waiver requests elimination of one or two of the three thermal tests (depending on the orbit temperature requirements of the specific component). The remaining thermal test (or tests) would be technically equivalent to the series of three thermal tests presently required.

The HAC system test plan for the T3 Dynamic Model and a HAC dipole test report of the traveling wave amplifier was received from NASA for GE's review. GE completed the review and comments to both documents were sent to NASA along with a revised vibration test requirement. (Systems Memo No. 018 Revision A dated February 23, 1965.)

Information has been received from HAC that spacecraft magnetic dipole tests will be performed on the prototype and all flight vehicles. Present plans for reducing excessive dipoles will be accomplished by either degaussing or installation of permanent magnets. (ATS Systems Memo No. 030 dated February 12, 1965.)

General requirements for all ATS temperature sensors have been defined including the expected temperature ranges. (ATS Systems Memo No. 032 dated February 25, 1965.)

2.2 BOOM SUBSYSTEM

2.2.1 PRIMARY BOOM DEPLOYMENT

In order to change the spacecraft inertial properties, the length of the gravity gradient rods must be varied in part of the ATS mission. The nominal length of the boom is 150 feet, and its minimum length, after initial deployment, is 50 feet. The same motor that deploys the primary boom initially is also used for the extension-retraction maneuvers. These boom movements are performed at the rate of 2 feet per second.

The motor is stopped almost instantaneously at the end of the retraction sequence, and the kinetic energy associated with the moving rod and tip mass must be absorbed. Since the extended rods become unstable at very low compressive loads, the question arises as to the structural adequacy of the rod itself and the effect on overall spacecraft behavior. An investigation was made to determine the effects of rod extension and retraction rates on the structural integrity of the primary booms. The investigation was based on the following simplifying assumptions:

1. Rods have no mass
2. Material is stressed below proportional limit
3. Small deflection theory
4. Spacecraft is undisturbed by shear and moment build-up at root of rod
5. Energy of the system is conserved
6. No lateral velocity of tip mass when system is stopped.

Using these assumptions, a set of equations was developed to express rod behavior and the problem was set up for computer solution. Results were obtained for rods stopped at the 50-foot length having tip weights of 10 and 2.6 pounds, retration rates of 2 and 3 feet per second, and initial tip eccentricities of 0, 15 and 30 inches.

Preliminary results indicate that stopping the booms at 50 feet was more severe than stopping at greater lengths, and that the maximum bending moments varied inversely as the square root of the length and directly as the velocity of retraction. The major results of the investigation indicate that the allowable bending moment will be exceeded with the 10-pound tip weight, and it is marginal with the 2.6-pound tip weight. The technical aspects of this analysis will be presented in the Third Quarterly Report.

An investigation was begun to eliminate the instantaneous stop which is causing the excessive bending moment. The work encompassed controlled acceleration profiles for starting and stopping the extension motor during normal and emergency modes. Results were presented at a meeting with Globe Industries and deHavilland Aircraft. A workable solution was agreed upon for acceleration control during normal mode operation that involves the incorporation of a control function into the Power Control Unit. Acceleration control is still under investigation for the emergency mode of operation.

2.2.2 ENVIRONMENTS

Analysis was performed to establish the thermal response of the damper boom mechanism from vehicle deployment to the time of damper boom erection. In performing this work an assumption was made for the temperature extremes of the boom mechanism at the time of vehicle deployment. Results indicated that a highly polished surface finish would maintain temperatures of the tip masses within tolerable limits for pre-extension periods up to 5 1/2 hours in duration. This condition holds for both MAGGE and SAGGE vehicles. However, in the case of the MAGGE vehicle where tip mass extension takes place two days after vehicle deployment, temperature variance of the tip masses is considerably widened. Accordingly, thermal control may require that the tip masses be thermally insulated on one or more of their surfaces. This will depend on a definition of tolerable temperature extremes by the boom mechanism subcontractor.

Temperature variance of the center package of the boom erection mechanism is affected by temperatures of the CPD and the internal vehicle structure. A maximum temperature of +90 F and a minimum temperature of +5°F is anticipated.

The center package of the boom mechanism will be thermally insulated to minimize heat leak from the CPD.

2.2.2.1 Assumptions

1. For the MAGGE vehicle, in orbit temperature variation of the inside surface of the aft solar cell extension panels is +140°F maximum and -100°F minimum.

2. For the spin stabilized SAGGE vehicle, temperature variation during launch of the inside surface of the aft solar cell extension panels is +70°F maximum and +30°F minimum.

3. The SAGGE vehicle maintains a spin mode during the launch profile.

4. The inside surfaces of the aft solar cell extension panels are not insulated. $\epsilon \approx 0.83$.

5. For SAGGE, time from vehicle deployment to erection of the damper booms is 5 1/2 hours.

6. For MAGGE, time from vehicle deployment to erection of the damper booms is 2 hours or 2 days.

7. Dimensions of the damper boom opening in the side of the MAGGE or SAGGE vehicle is 5' x 5 1/2" (rectangular).

8. The initial temperatures of the boom erection mechanism at the time of vehicle deployment is taken as +100°F maximum and +20°F minimum.

9. A vapor deposited aluminum finish can be attained ($\epsilon \approx .04$) for each surface of the damper booms erection mechanism.

10. The center package of the damper mechanism will be thermally insulated to minimize heat leak from the CPD.

2.2.2.2 Thermal Performance, MAGGE Vehicle

Maximum temperature of tip mass after 2 hours = +125°F

Minimum temperature of tip mass after 2 hours = +14°F

Maximum temperature of tip mass after 2 days = +174°F

Minimum temperature of tip mass after 2 days = -56°F

Center package of boom erection mechanism

maximum temperature = +90°F
minimum temperature = +5°F

2.2.2.3 Thermal Performance, SAGGE Vehicle

Maximum temperature of tip mass after 5 1/2 hours = +105°F

Minimum temperature of tip mass after 5 1/2 hours = +5.0°F

Center package of boom erection mechanism

maximum temperature = +90°F
minimum temperature = +5°F

Validity of these findings is dependent upon the assumptions made in Items 1 through of paragraph 2.2.2.1.

2.2.3 TELEMETRY

An investigation was completed into the optimum pressure transducer for use in the Boom Subsystem with particular regard to simplicity in curcuitry required in the Power Control Unit. The transducer selected is a potentiometer type supplied by the Computer Instrument Corporation. This instrument meets ATS environmental specifiecations and delivers an output from 0 to -5 volts as required by ATS telemetry. GE is specifying a range of 0 to 25 psia in order to allow for pressurization up to one atmosphere above design level as required by ATS environmental specifications.

2.2.4 TV TARGETS

In order to simplify the design of the boom tip target (TV target) attachment, it has been proposed that the targets remain fixed to the booms at the angle required for stowage, flush to the vehicle "skin" during boost. This angle has been determined to be 50 degrees to the rod centerline. Although the target will have a preferred orientation with respect to the vehicle axis during launch, it is best to assume that orientation about the rod centerline is the worst case due to rod twisting.

The adequacy of this suggested design is dependent on the effect it will have on the TV Camera requirements since substantial light loss is caused by the 50-degree target mounting angle.

2.2.5 SUBSYSTEM INTERFACE

Definitions have been established at the Damper Boom/CPD interface with respect to the mountings of boom deployment monitor switches and wire harness latch-down device on the top surface of the CPD. Further design is in process to define the interface more precisely.

2.2.6 SUBCONTRACT ACTIVITIES

A preliminary definition of the Boom Subsystem for both the thermal and dynamic models (T2 and T3) was prepared by the resident deHavilland Systems Engineer in conjunction with GE Thermal and Dynamic Analysis groups. The document was submitted for GE project acceptance before it is sent to deHavilland.

2.3 COMBINATION PASSIVE DAMPER (CPD)

2.3.1 SUMMARY

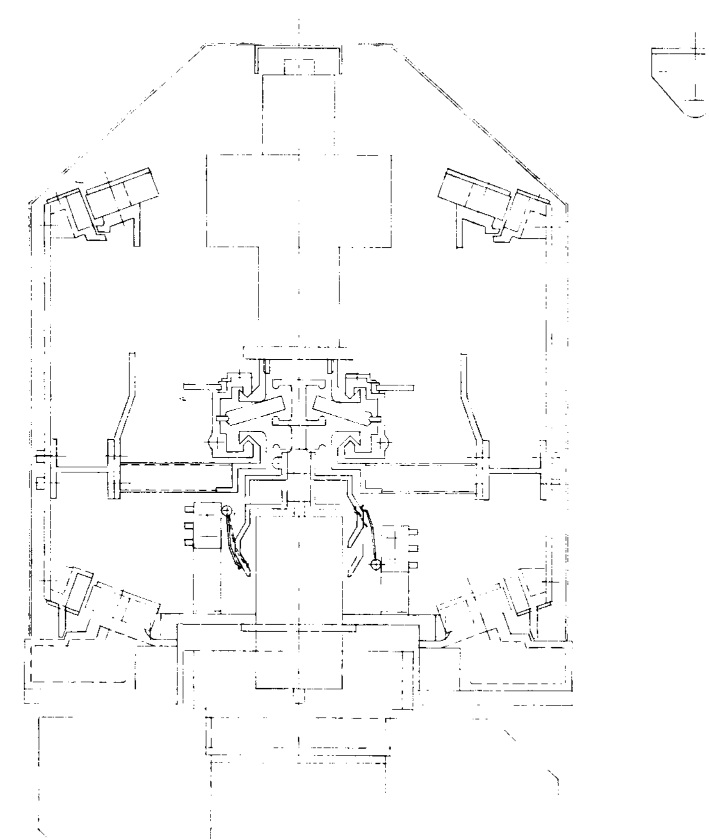
Major events for the month include:

1. The first in-house Design Review of the CPD was held 12 February at GE.

2. Received NASA direction (February 17, 1965) to buy the hysteresis damper for use in the CPD.

3. The method of caging the damper boom and the eddy current damper was questioned from a reliability standpoint, and redesign studies were initiated on February 26, 1965.

4. Redesign of the caging mechanism will necessitate lengthening the overall CPD package. In view of the proposed changes in the HAC vehicle; it has been assumed that the package may be changed as required for a new caging mechanism.



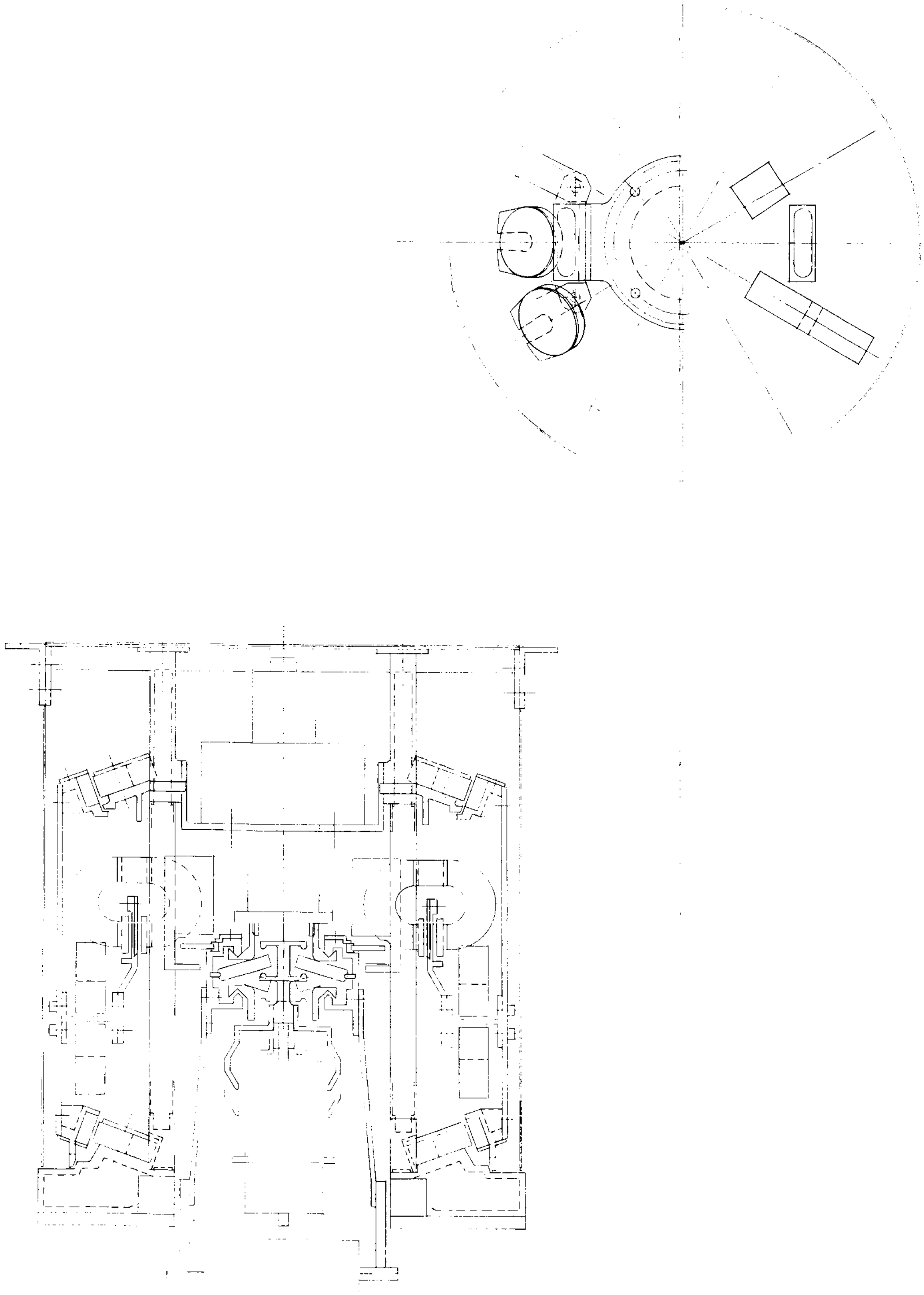
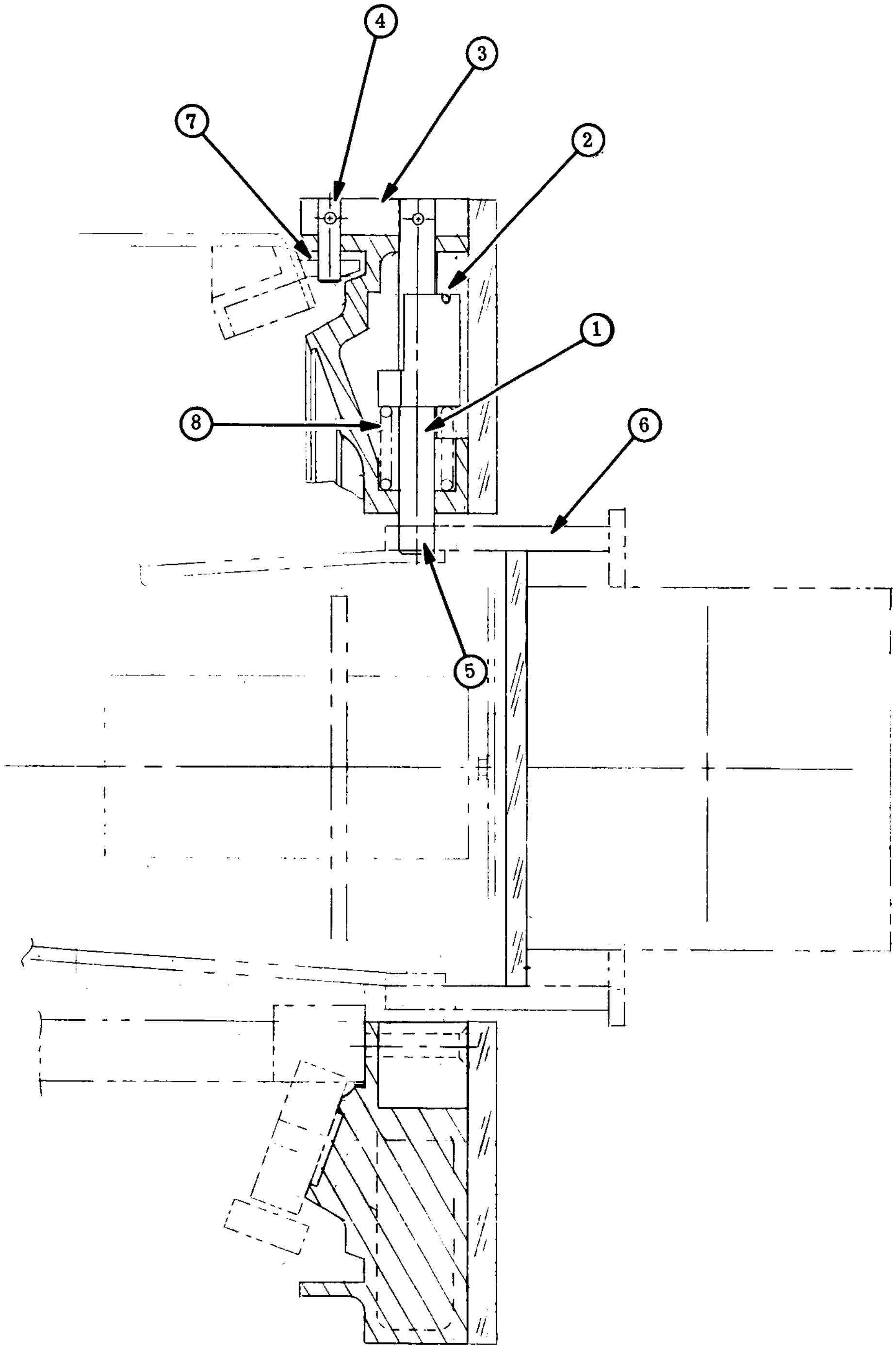


Figure 1. Combination Passive Damper Stage III Arrangement (GE Dwg SK 56130-808-41)

2



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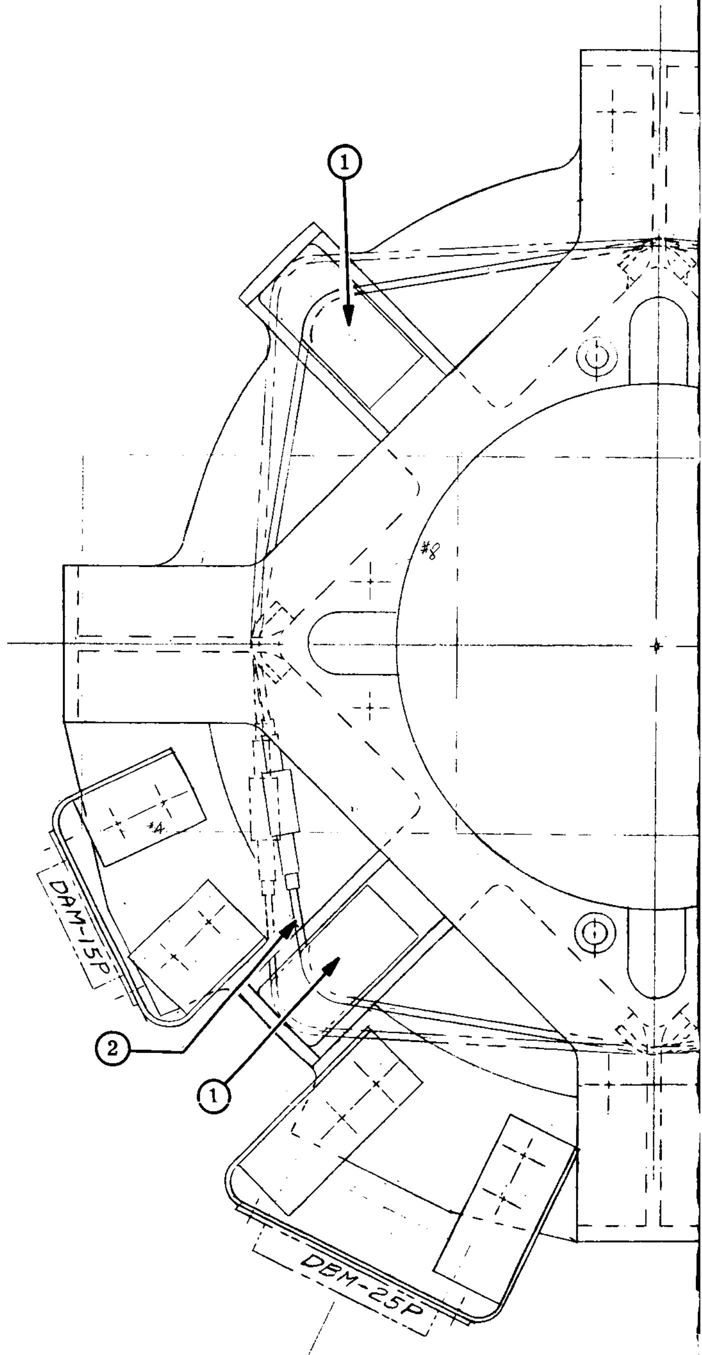
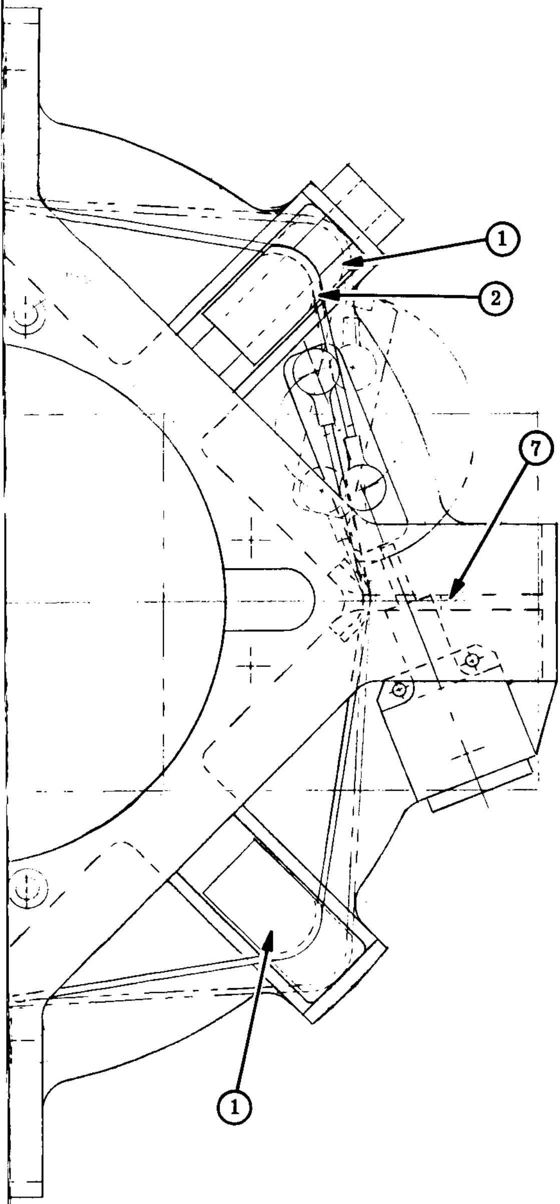


BOTTOM VIEW

2



WITHOUT 1/4" BLANKET

Figure 2. Current Boom Caging Mechanism
(GE Dwg SK 56130-808-42)

2.3.2 DESIGN EFFORT

2.3.2.1 Configuration Status

The first Design Review for the CPD was held at GE on February 12, 1965. This design is shown in Figure 1. In attendance at the Design Review meeting were Mr. L. G. Gitzendanner and Mr. B.D. Bedford, Consulting Engineers from General Electric Advanced Technology Laboratories, Schenectady, N.Y. as well as a number of engineers from the Spacecraft Department. Comments brought up during the Design Review are being reviewed and action taken where required. No major discrepancies in the CPD design were uncovered during the review.

As a result of a policy discussion from NASA, GE has initiated action to procure the hysteresis damper from TRW Space Technology Laboratories.

The method of caging the damper boom and the eddy current damper is being reviewed, and a major change to the current CPD configuration may result from any resulting redesign. The current boom caging system as shown in Figure 2, consists of four spring loaded pins ① which are restrained during launch by a cable② . Built onto these four prime boom caging pins are appendages③ containing smaller pins④ which cage the eddy current damper. All pins fit into straight holes on the boom structure⑤ and damper ⑥respectively. Upon cable slacking (as the result of activation of pyrotechnic dimple motors)⑦,the pins are withdrawn from the holes by individual springs⑧of approximately 50-pound force. The normal withdrawal force is carefully controlled at assembly to be in the order of ounces. This system was selected over other methods because of its compactness, simplicity and similiarity to release mechanisms used successfully on the Nimbus project. The reliability of this system was questioned based on the possibility of "cocking" action, burrs, etc., which might prevent the withdrawal of any one of the eight pins involved. It was recommended by the customer that a "Marman Clamp" type approach be studied, and to alleviate the severe space restrictions formerly imposed on the design, a ground rule was established that the CPD overall envelope could be enlarged if necessary. This tentative relaxation of space restrictions and envelope size was based on the recently proposed redesigned HAC vehicle which allows more space in the CPD area. Other caging approaches are also being studied.

Final revisions to Specification SVS-7331 for the Passive Hysteresis Damper have been made and the document will be issued early in March. Modification to the specification for the complete Combination Passive Damper (SVS-7314) are in process. It is planned to issue this specification later in March.

2.3.2.2 Diaphragm Clutch

Data for force vs. displacement curves for the diaphragm was taken. Two diaphragms were evaluated; each diaphragm was a 12-lobe, square plate design but the thicknesses were different. Both designs showed a reduction in force output after having been cycled 200 times (as compared to an expected 60 cycles in orbit and an additional 40 cycles in ground testing). The thicker diaphragm showed a reduction of about 20% in force vs displacement and the thinner model had a 10% reduction. This change is attributable to the material yielding in the highly stressed areas but there was no signs of fatigue cracks. Another design is being prepared which incorporates stress-reducing slots.

2.3.3 DEVELOPMENT ENGINEERING ACTIVITIES

2.3.3.1 Eddy-Current Damper

Tests were run during February to evaluate the amount of hysteresis damping which was present in the magnetic torsioned restraint element of the eddy-current damper. It was determined that the hysteresis loss observed when the rotor was rotated through the full $\pm 45^{\circ}$ range was about 10% of that loss which is specified as the design goal of an equivalent hysteresis damper. This 10% value of hysteresis loss has been included in the eddy-current damper specification. However, it was also found that if the rotation of the rotor was kept within $\pm 10^{\circ}$ (a condition which more nearly simulates actual orbit operation after initial settling of the space vehicle) the hysteresis loss was well within the $\pm$10% limit.

In an effort to achieve further reduction of the hysteresis damping, flux in the air gap was reduced and the configuration of the magnetic pole pieces was changed. These changes reduced hysteresis loss but also caused a loss in linearity of the curve of displacement vs torsional restraint torque.

It had been found previously that the optimum configuration of the damper required the use of a copper damping disc. If the flux in the air gap in which the disc rotated could be increased sufficiently, then it could be possible to use an aluminum damper disc with its attendant weight advantage. One technique which appeared worthwhile was to increase the length of permenent magnets used to provide the flux. However, in the tests performed it was determined that no appreciable increase in flux density was obtained with longer magnets (the longer magnets would still fit within the present configuration).

Another series of tests demonstrated that, if the magnets used for the eddy-current damper are not positioned properly with respect to the magnetic torsional restraint element, its functional characteristics will be adversely affected. The layout of the parts of the eddy-current damper were rearranged to permit optimum location of the critical parts, especially the location of the damping magnets with relation to the torsional restraint magnets. Subsequent tests confirmed that the new layout reduced the adverse effects to about 10% of their original value.

Values were established for all design parameters for the diamagnetic suspension, resulting in a design of the suspension which will support all the expected external and internal loads. Sensitivity coefficients were computed which indicate the extent of performance degradation associated with deviations from the established value for each design parameter.

2.3.3.3 Hysteresis Damper

A series of tests was conducted to measure the load carrying capabilities of an engineering model of the hysteresis damper. To perform these tests, the Low Order Force Fixture (LOFF) was used as shown in Figure 3. In the radial force vs displacement tests, it was found that characteristic curve was identical regardless of the radial

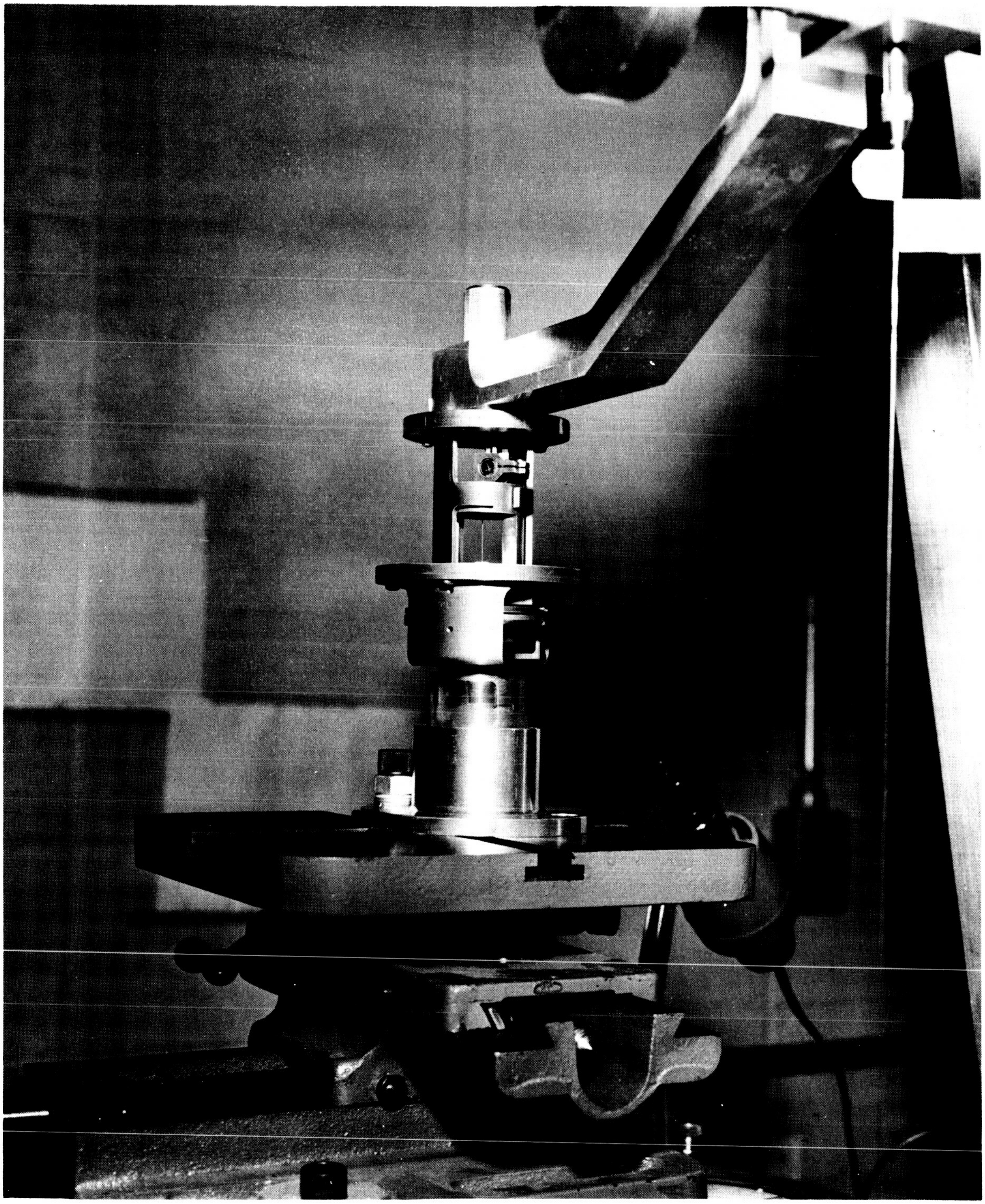


Figure 3. Load Carrying Capability Measurement Test Setup on the Low-Order Force Fixture

direction from which this force was applied. This characteristic was also checked with the damper rotated about 40^{o} and again found to be identical. In the "cocking" or overturning torque tests, it was found that the theoretical design value was about 5% under the value actually measured but that this measured value was about 10% above the force specified. The discrepancy was due to the limitations of engineering type calibration equipment in accurately setting the "flex-pivot" suspension system during assembly. This limitation would not exist in fabrication of qualification and flight hardware. No axial force measurements were made because the stiffness in this direction far exceeds the minimum specified and, in fact, exceeds the capacity of the LOFF to measure the axial force.

2.3.3.3 Subcontract Activities

2.3.3.3.1 Angle Detector

Dynamics Research Corporation (DRC) has completed their work on the initial design of the angle detection system and submitted a report covering the effort. Including in the initial design effort was the preparation of a block diagram, circuit design for critical elements, a brief analysis of their circuit design and preliminary mechanical drawings of the hardware. Their electronic circuits were discussed with GE electronics consultants who made recommendations regarding circuit simplification, reliability improvement and stabilization. Their work also included preparation of a cost proposal. The cost figure submitted was approximately 65% higher than their previous estimate. Discussions with DRC personnel indicate that possibly they did not realize the seriousness of many of the problems of the detector and only after they had completed the initial design phase were they able to fully evaluate the effect of all design requirements.

Because of the high cost of this proposal, GE is again looking at the possibility of "making" rather than "buying" this item. A design study is under way to prepare a feasible design and determine what the cost might be to make this detector.

2.3.3.3.2 Solenoid

The quotations of three vendors (G. W. Lisk, Anderson Controls, and Koontz-Wagner) appear to have considerable merit. While the first vendor has taken exception to the size of the component if the force vs travel specification is to be met, the other two vendors have stated that they can meet all requirements. Because it is felt that these two vendors have not thoroughly analyzed the specification and to appraise the relative competence of these vendors, it is planned to visit all three and discuss the design.

It has been decided that power to the solenoid will be regulated to -24 volts to $\pm$ 2.5 volts. This regulation was found to be necessary to prevent size and weight of the solenoid from becoming completely accpetable.

2.3.3.4 Test Equipment

The air bearing for the Advanced Damping Test Fixture(ADTF) was received and acceptance tested. Motoring torques in the bearing were measured and found to be appreciably less than the 1 dyne-cm specified. Data was also taken to determine the gas supply pressure to be used when operating with various loads suspended from the bearing to maintain the motoring torques near zero value. The torques pick-off parts which are to be used with the air bearing have been installed and preliminary tests were started.

The vendor has experienced some difficulty in obtaining a satisfactorily seat for the air bearing to be used with the second LOFF. Delivery of this unit has been rescheduled for late in March.

2.4 ATTITUDE SENSOR SUBSYSTEM

2.4.1 SOLAR ASPECT SENSOR

An internal design review was held on February 26th to discuss the electronics, packaging and thermal design as well as the optical design. The temperature limits of the new satellite configuration do not present a problem, but an unresolved area may be an apparent incompatibility between the thermal coating and the optical alignment surface.

2.4.1.1 Analytical Activities

A change in the requirements to Specification SVS-7325 was investigated to lower the 3-year drift on film resistors. The new limits are ±3% for carbon film resistors and ±1% for precision metal film resistors.

The use of tape cable to interconnect the printed circuit boards in the SAS electronics unit was discussed with Reliability Engineering. No problems are forseen with Adcole's application. However, the topic will be given further study. Adcole was instructed to use commercial cable connectors (no gold plating) on the wooden, thermal and structural models of the Solar Aspect Sensor.

2.4.1.2 Subcontract Activities

The following items pertaining to the Solar Aspect Sensor subcontract were discussed with Adcole during the month:

1. Status of the optical and electrical design
2. Effects of Specification SVS-7325 on the electronic design and the accuracy
3. Testing to be done by Adcole and the test equipment to be used
4. Method of alignment and reference marks
5. Method of measuring each sensor temperature and the detector to be used.

2.4.2 TV CAMERA SUBSYSTEM

2.4.2.1 Video Bandwidth

Studies of video output bandwidth were continued during February. Three video bandwidth filters (on loan to GE from NASA/GSFC) were used with a Lear-Seigler Camera System

(Model 0431B) to limit the bandwidth to 1.5, 2.5 and 3.5 mc/s. For comparison, tests were also conducted at a full bandwidth of 6 mc/s using no filter. Photographs were taken of the monitor and oscilloscope presentation of a model TV target 1.2 inches in diameter. Results of these tests are shown in Figure 4 for the different illumination angles at bandwidth of 3.5 mc/s and at 6 mc/s.

The cutoff frequency and rolloff rate of the 3.5 mc/s filter closely approximates the requirements of the TV camera specification. Additional tests were started using injected noise, but the nose generating equipment was not capable of producing a signal-to-noise ratio worse than 30 db with the filters in.

GE was directed by NASA/GSFC to use a video baseband which is 3 db down at 3.5 mc/s and approximately 60 db down at 60 mc/s.

It was agreed that an output signal to noise ratio of 30 db after detection will be sufficient to give a good probability of detecting the booms.

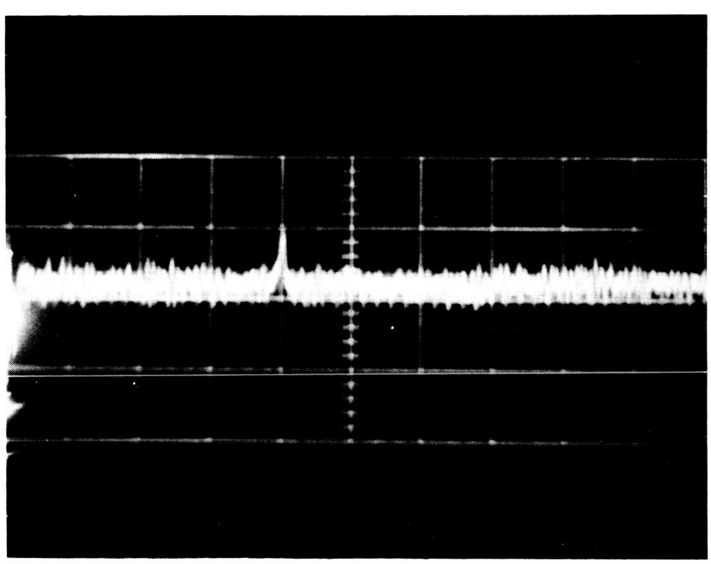
The time required to exhaust the cameras and electronics unit below the critical corona pressure was calculated as a function of the size of the venting port. As a result of these investigations and discussions of venting requirements with NASA/GSFC during the month, the component specification was revised to incorporate a change in the depressurization requirement.

2.4.3 POWER CONTROL UNIT

2.4.3.1 Breadboard Construction

Wiring of the component breadboard model and engineering test rack was completed, except

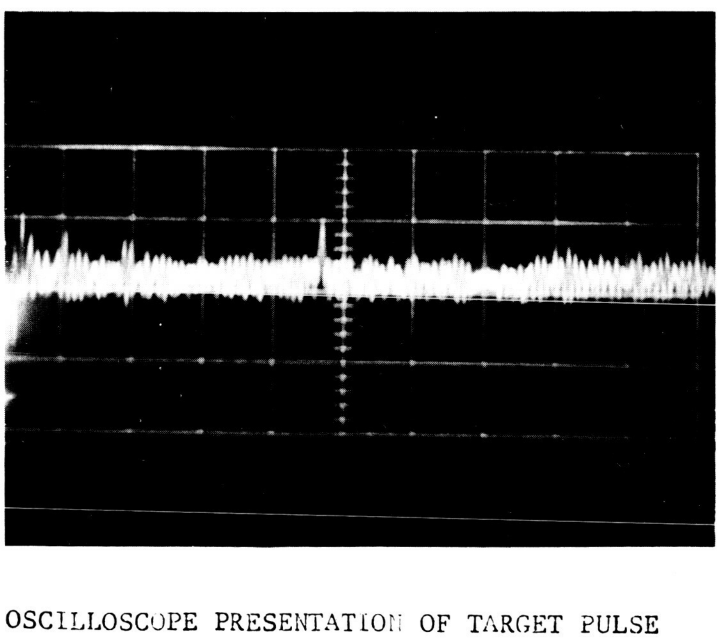
WHITE TARGET
WORKING DISTANCE: 1.2 IN. DIA TARGET AT 20 FEET
TARGET SURFACE INCLINED 45° TO CAMERA LINE OF SIGHT
ILLUMINATION: 178 FOOT-CANDLES ON TARGET
LIGHT INCLINED 15° OFF CAMERA LINE OF SIGHT
BANDWIDTH 6 MC/S (WITHOUT FILTER)



OSCILLOSCOPE PRESENTATION OF TARGET PULSE
SWEEP: 0.5 VOLT/CM VERTICAL DEFLECTION
2 μSEC/CM HORIZONTAL DEFLECTION

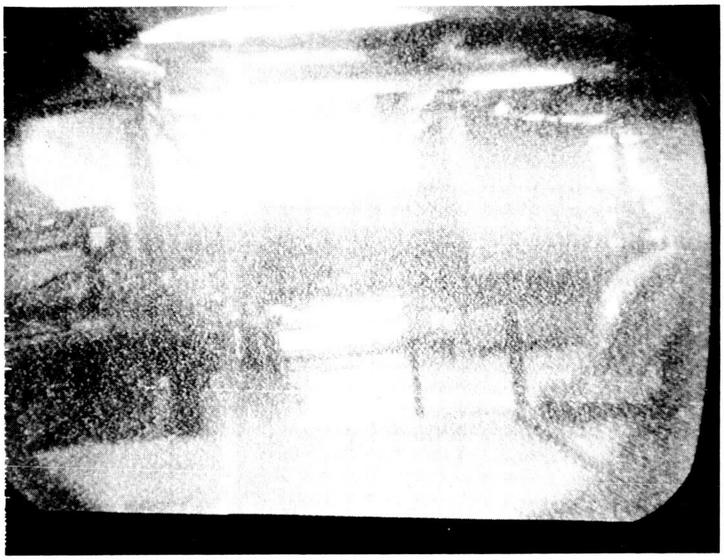
Figure 4. Video Bandwidth Test Results (Sheet A)

WHITE TARGET
WORKING DISTANCE: 1.2 IN. DIA TARGET AT 20 FEET.
TARGET SURFACE INCLINED 45° TO CAMERA LINE OF SIGHT
ILLUMINATION: 178 FOOT-CANDLES ON TARGET
LIGHT INCLINED 15° OFF CAMERA LINE OF SIGHT
BANDWIDTH 3.5 MC/S (WITH FILTER)

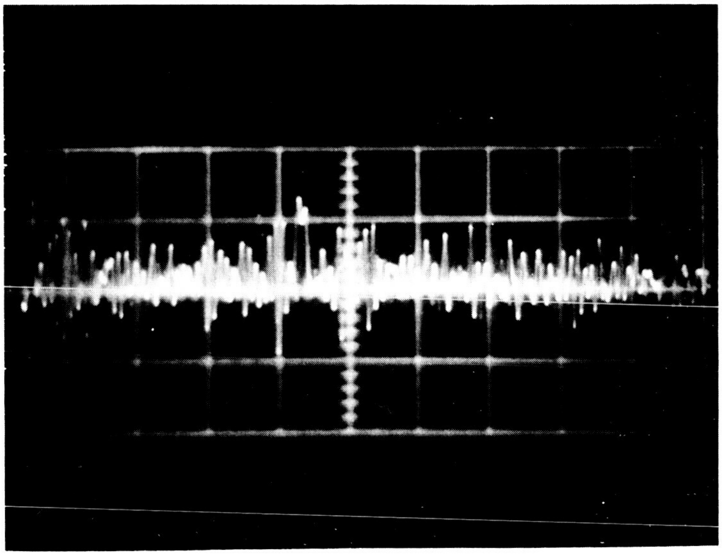


OSCILLOSCOPE PRESENTATION OF TARGET PULSE
SWEEP: 0.5 VOLT/CM VERTICAL DEFLECTION
2 μSEC/CM HORIZONTAL DEFLECTION

Figure 4. Video Bandwidth Test Results (Sheet B)



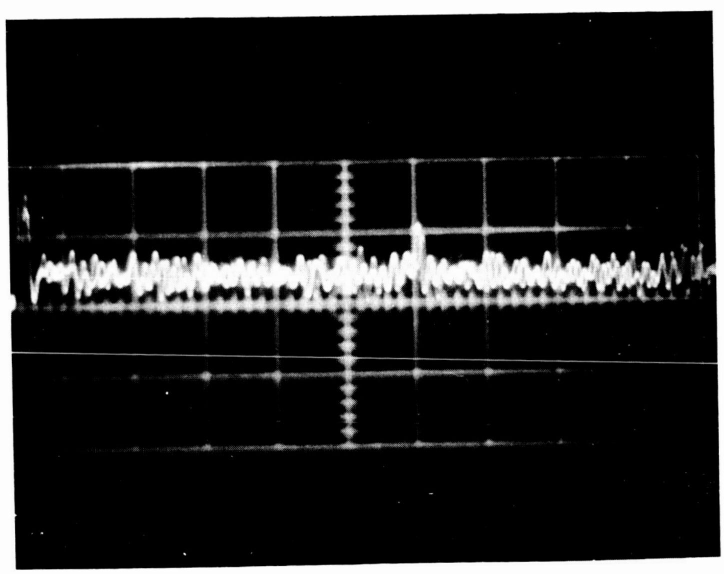
WHITE TARGET
WORKING DISTANCE: 1.2 IN. DIA TARGET AT 20 FEET
TARGET SURFACE INCLINED 45° TO CAMERA LINE OF SIGHT
ILLUMINATION: 178 FOOT-CANDLES ON TARGET
LIGHT INCLINED 30° OFF CAMERA LINE OF SIGHT
BANDWIDTH: 6 MC/S (WITHOUT FILTER)
SIGNAL-TO-NOISE RATIO: 15 DB



OSCILLOSCOPE PRESENTATION OF TARGET PULSE
SWEEP: 0.5 VOLT/CM VERTICAL DEFLECTION
2 μSEC/CM HORIZONTAL DEFLECTION

Figure 4. Video Bandwidth Test Results (Sheet C)

WHITE TARGET
WORKING DISTANCE: 1.2 IN. DIA TARGET AT 20 FEET
TARGET SURFACE INCLINDED 45° TO CAMERA LINE OF SIGHT
ILLUMINATION: 178 FOOT-CANDLES ON TARGET
LIGHT INCLINED 30° OFF CAMERA LINE OF SIGHT
BANDWIDTH: 3.5 MC/S (WITH FILTER)

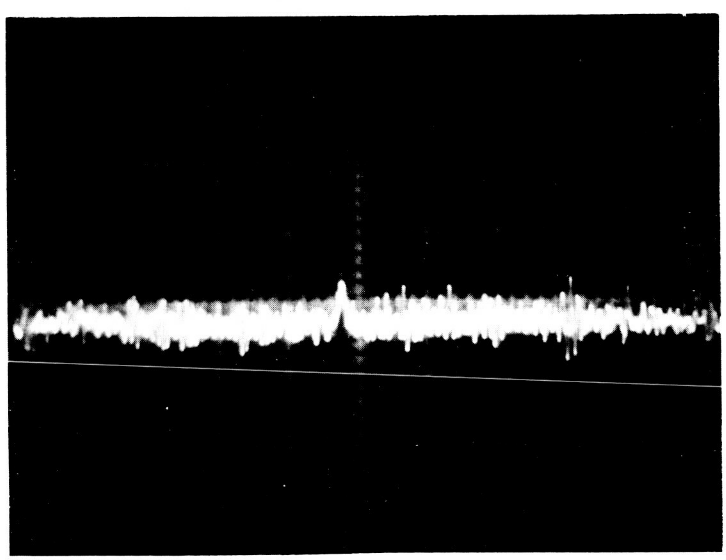


OSCILLOSCOPE PRESENTATION OF TARGET PULSE
SWEEP: 0.5 VOLT/CM VERTICAL DEFLECTION
2 μSEC/CM HORIZONTAL DEFLECTION

Video Bandwidth Test Results (Sheet D)

Figure 4. Video Bandwidth Test Results (Sheet D)

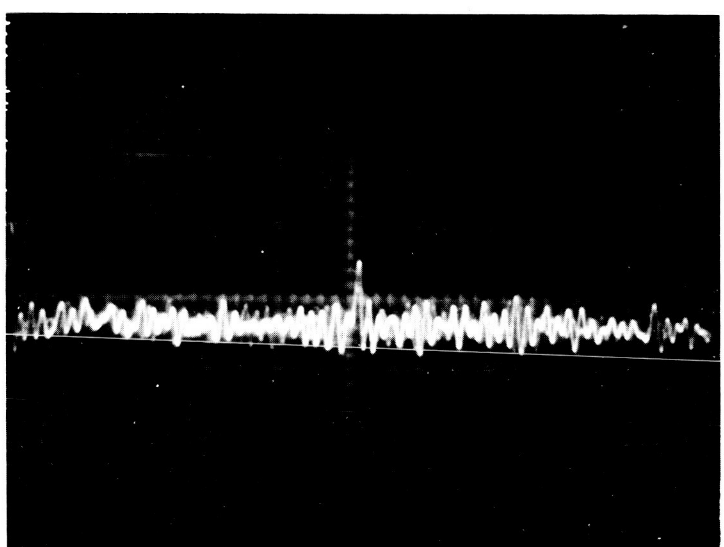
WHITE TARGET
WORKING DISTANCE: 1.2 IN. DIA TARGET AT 20 FEET
TARGET SURFACE INCLINED 30° TO CAMERA LINE OF SIGHT
ILLUMINATION: 178 FOOT-CANDLES ON TARGET
LIGHT INCLINED 45° OFF CAMERA LINE OF SIGHT
BANDWIDTH: 6 MC/S (WITHOUT FILTER)
SIGNAL-TO-NOISE RATIO: 23 DB



OSCILLOSCOPE PRESENTATION OF TARGET PULSE
SWEEP: 0.5 VOLT/CM VERTICAL DEFLECTION
2 μSEC/CM HORIZONTAL DEFLECTION

Figure 4. Video Bandwidth Test Results (Sheet E)

WHITE TARGET
WORKING DISTANCE: 1.2 IN. DIA TARGET AT 20 FEET
TARGET SURFACE INCLINED 30^{o} TO CAMERA LINE OF SIGHT
ILLUMINATION: 178 FOOT-CANDLES ON TARGET
LIGHT INCLINED 45^{o} OFF CAMERA LINE OF SIGHT
BANDWIDTH: 3.5 MC/S (WITH FILTER)
SIGNAL-TO-NOISE RATIO: 23 DB



OSCILLOSCOPE PRESENTATION OF TARGET PULSE
SWEEP: 0.5 VOLT/CM VERTICAL DEFLECTION
2 μSEC/CM HORIZONTAL DEFLECTION

Figure 4. Video Bandwidth Test Results (Sheet F)

for the separation timer, modifications required for motor speed control and possible changes to the event ladders. Preliminary testing was performed to demonstrate immunity to conducted interference in the low to medium frequency range (50 cps to 10 Kc/s).

2.4.3.2 Mechanical Design

An updated parts list, based on the latest schematic, is being prepared so that advance ordering of prototype and flight parts can begin. An order to hold the assembly of the modules associated with the temperature sensors was issued pending resolution of the type of temperature detectors to be used.

2.4.3.3 Electrical Design

Preliminary design is being continued in the areas of the separation timer, motor speed control and regulated pulse driver for the CPD clutch solenoid. The use of HAC temperature sensors may require some modifications to the telemetry monitoring resistors and reference power supply.

Since the electromechanical brake in the armature circuit of the extension and scissoring motors was presenting a considerable problem in the speed control at low voltages, it has been decided to put the brake in shunt, parallel to the field winding. A series resistor may be cut into the circuit as the brake releases to reduce its holding current drain. Speed control will be open loop by varying the applied voltage according to a predetermined linear relation without sensing the motor current.

It has been agreed with NASA/GSFC to use a discrete command with a duration of 100 milliseconds to operate the CPD clutch solenoid, rather than a squib-type command with a 50-millisecond duration. Since the HAC current limiter will open at a current drain of 10 amperes for greater than 500 milliseconds, no danger exists of burning out the solenoid by the application of a long-duration execute pulse.

The logic for video switching is presented in Figure 5.

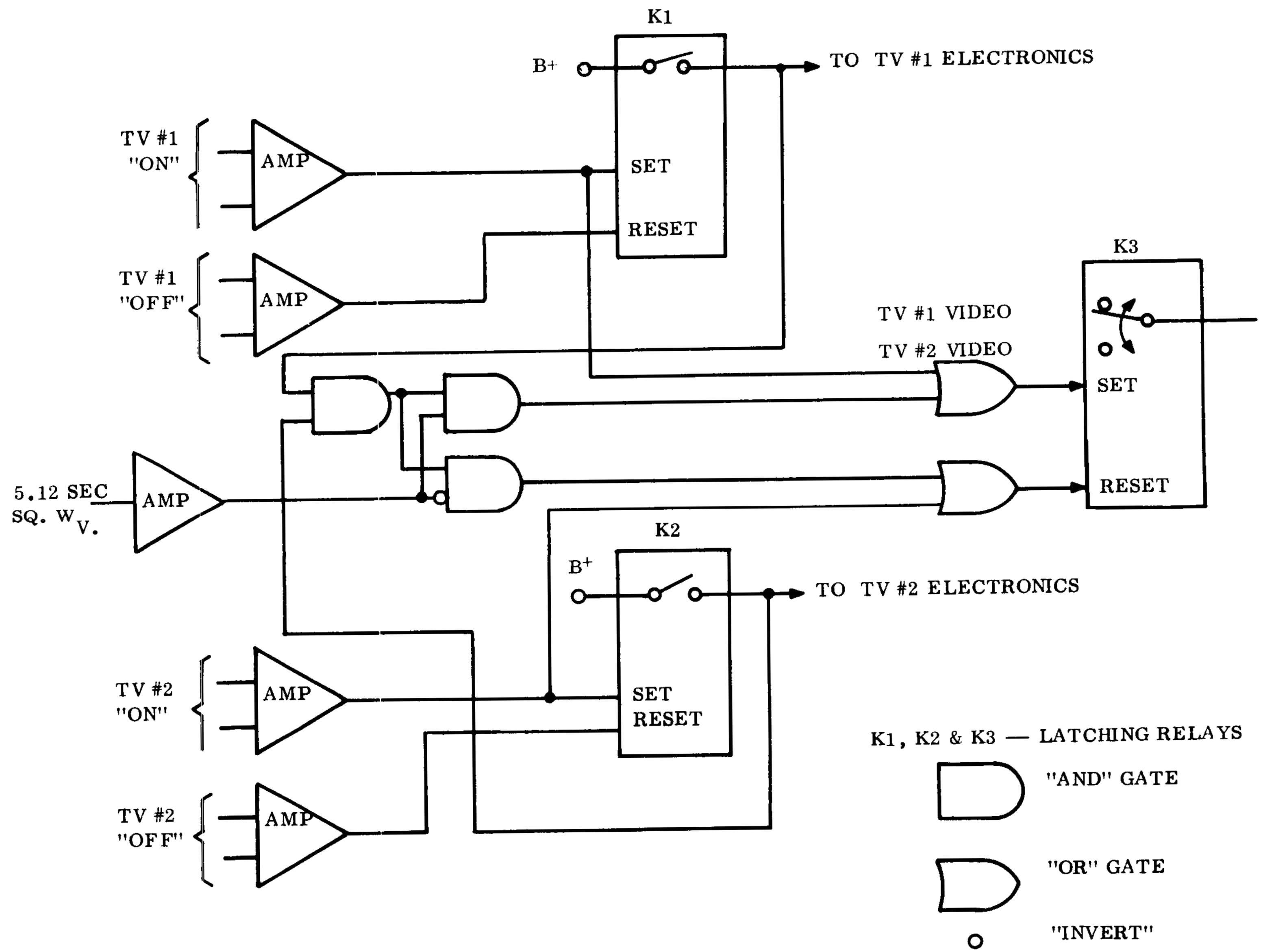


Figure 5. Logic Diagram-Video Switch

2.4.3.3 Component Specification

A preliminary component specification was released and distributed for review. Comments will be incorporated into the final document.

2.5 QUALITY CONTROL

2.5.1 ALIGNMENT TESTING

As reported in paragraph 2.1.7, Testing, results of the recommended method for aligning ATS components were marginal. Since then, a program was presented for review by Design Engineering for assuring proper alignment. The program will be implemented by Engineering and Manufacturing. Details will be presented in a subsequent report.

2.5.2 BOOM SUBSYSTEM

An internal design review was conducted by members of the Quality Control and Test Equipment Engineering group for the Primary Boom Test Panel. Comments made during the review are to be incorporated into the final design.

Test Requirement TR No. 11007 was issued; it defines the equipment required to perform Engineering Qualification and Acceptance tests that are presently planned.

2.5.3 COMBINATION PASSIVE DAMPER

Test Requirement No. 11008 was issued which defines the equipment for damper testing.

2.5.4 ATTITUDE SENSOR SUBSYSTEM

Details of the Quality Control requirements for the manufacturing and testing of the Solar Aspect Sensor were discussed at the Adcole Corporation facility. Corrections of previously noted problems were reviewed.

2.5.5 MATERIALS AND PROCESSES

The bearing sizes dictated by the design of the rod deployment mechanism prevent use of normal techniques in applying the recommended dry film lubricant to all bearing surfaces.

Torsion wire springs were assembled into the GE working model that was presented at the NASA debriefing session of the STL damper on February 2, 1965.

Tensile samples were cut from annealed 0.012-inch thick BeCu stock to be used as the Belleville spring in the clutch mechanism of the Combination Passive Damper. The samples will be heat treated with the actual piece parts.

SECTION 3.

RELIABILITY

A review was made of prior test data available through the Interservice Data Exchange Program documentation, the listings by the Battelle Institute and GE parts history data in preparation for an item by item review of the Parts Qualification tasks.

Available parts cost information and testing costs were reviewed, and an analysis was prepared of the reliability risks and mission criticality based upon the times given in the orbit test plan. These factors have been combined to provide a weighted figure of merit by which the relative contribution of "PARTS QUAL" testing effort per line item can be judged in arriving at a final program cost and plan.

A similar tradeoff study was made for line items involved in the deHavilland Drive Unit. In this study, a complete unit was used as a "test bed" for parts qualification testing in combination with the testing of reduced numbers of individual part specimens.

Results of these Reliability investigations will be available in March. They will be published in detail in the Third Quarterly Progresss Report.

SECTION 4.

SPECIFICATION STATUS

The following lists the number and title for each component specification associated with the ATS Gravity Gradient Stabilization System. The Space Vehicle Specification (SVS) number designates the particular document which is recorded and controlled within the GE Spacecraft Department.

Specification No.	Title	Status
SVS-7306	Solar Aspect Sensor-ATS	Revision A 12/22/65
SVS-7307	Power Control Unit-ATS	Review (Awaiting Comments)
SVS-7310	TV Camera Subsystem-ATS	Review
SVS-7314	Combination Passive Damper	Review
SVS-7315	Angle Detector	12/31/64
SVS-7316	Boom Subsystem	Review
SVS-7325	Standard Parts, Materials and Processes, Use of	Revision C 12/31/64
SVS-7331	Passive Hysteresis Damper	Review
SVS-7338	Standards, Engineering Equipments	1/12/65

SECTION 5.

SCHEDULES

The schedule for the systems to be delivered for use by the spacecraft contractor is currently being evaluated to establish the effect of changing the hysteresis damper from a "make" to a "buy" item. Preliminary evaluation indicates that the delivery for the systems will be as follows:

Engineering Unit	(T4)	15 October 1965
Prototype Unit		15 April 1966
Flight Unit No. 1	(F1)	15 September 1966
Flight Unit No. 2	(F4)	15 October 1966
Flight Unit No. 3	(F5)	15 November 1966

These dates will be verified upon completion of the negotiations with the hysteresis damper vendor. It is estimated that the negotiations and schedule updating will be completed during the next reporting period.

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